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(54) Multi-stage centrifugal pump

(57) A low-speed L.P. stage 1 and one or more high-speed H.P. stages 2 are located in a common housing 5 and independently driven. The driving motors 7 of the H.P. stage(s) may be of higher speed than the driving motor 9 of the L.P. stage. The motors may be of frequency-controlled three-phase type or may be of D.C. type fed with rectified current from a three-phase supply, or I.C. engines or turbines may be used.

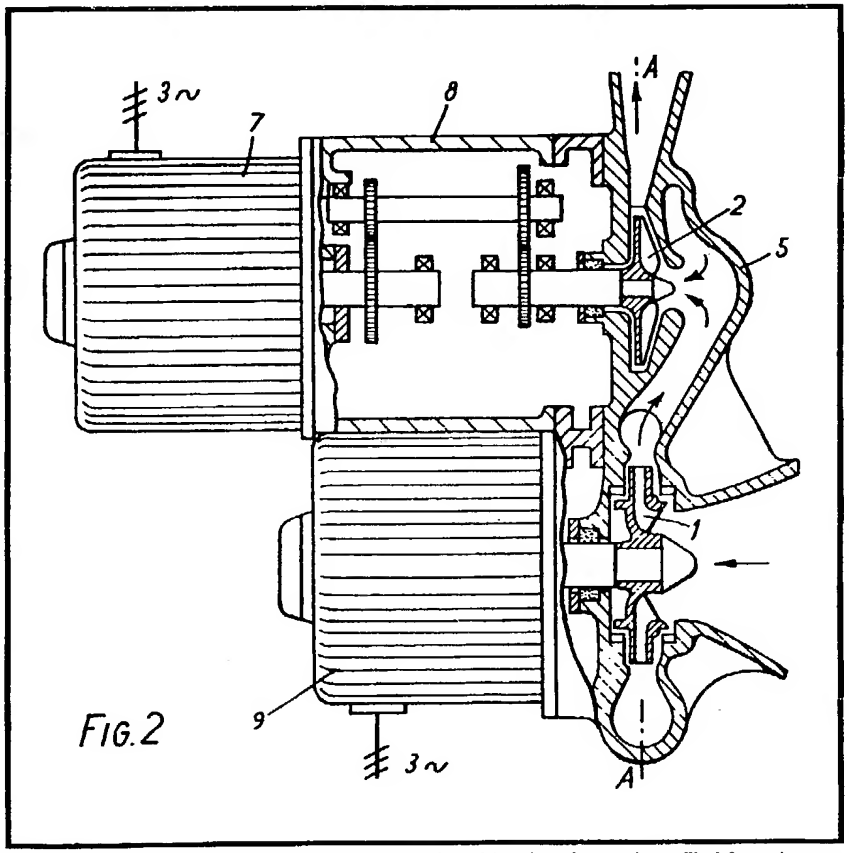
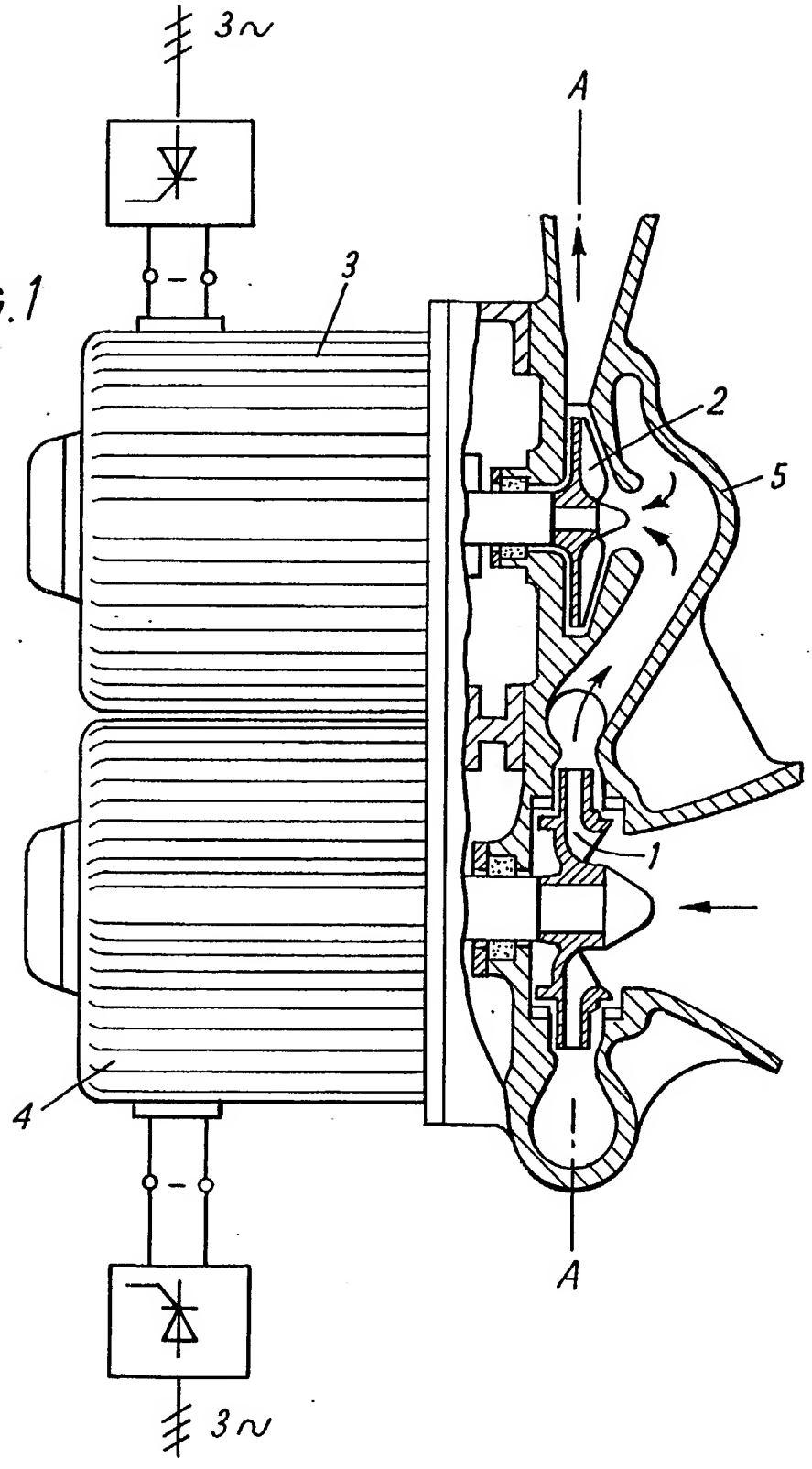


FIG.2

GB 2 023 731 A

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

FIG.1



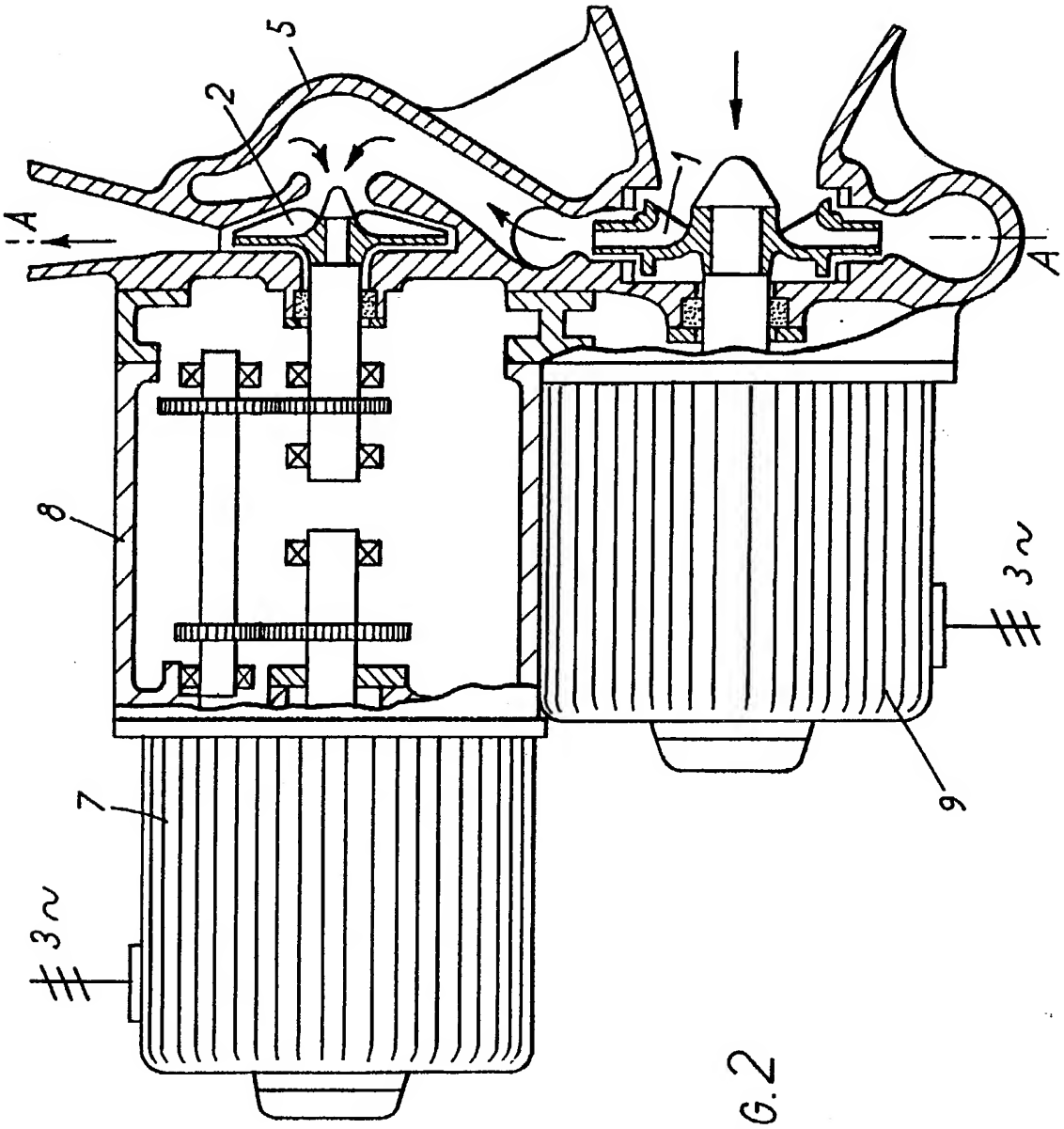
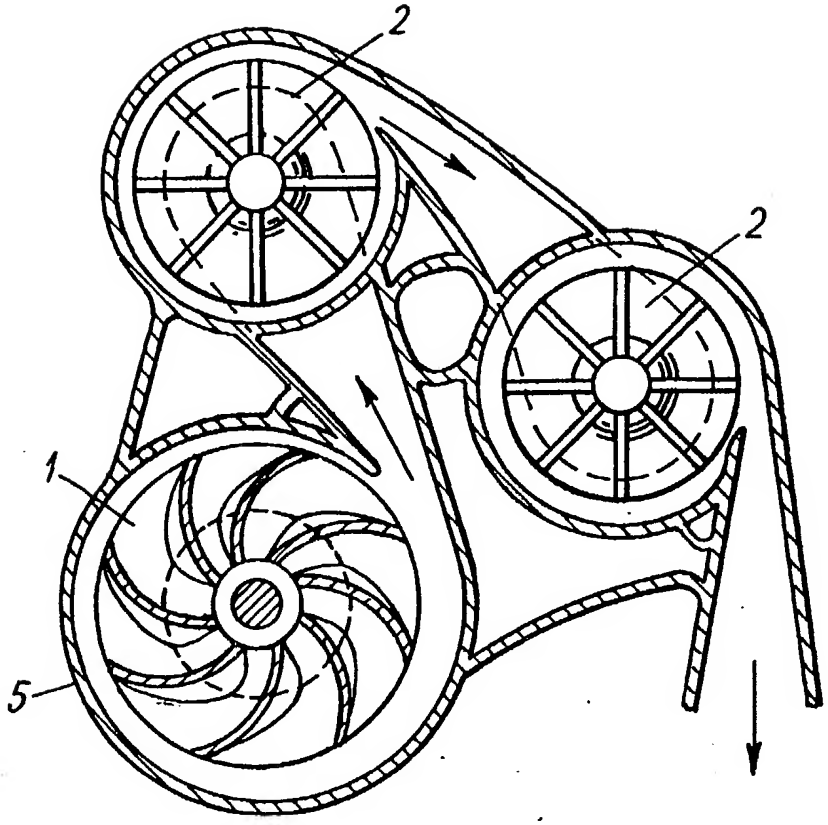


FIG.2

FIG.3



SPECIFICATION

High-pressure centrifugal pump assembly

The invention relates to a multi-stage high-pressure centrifugal pump assembly of a vertical or horizontal construction for the delivery of liquids to relatively high delivery heads.

The pumps of the centrifugal pump assemblies by which liquids are delivered to relatively high delivery heads are mainly designed as multi-stage centrifugal pumps containing up to 15 stages. The electric prime mover which is mainly used is a three-phase induction motor with an upper limiting speed of $n_{syn} = 3000\ min^{-1}$ determined by the mains frequency of 50 Hz (European mains system) and $n_{syn} = 3600\ min^{-1}$ at 60 Hz (North American mains system). It is also usual to arrange a gearing between the electric prime mover and a multi-stage centrifugal pump in order to increase the speed of rotation, so as to achieve a higher speed than $3000\ min^{-1}$ for driving the pump. (Technical Handbook "Pumpen", VEB Verlag Technik Berlin, 5th Edition 1976; Kleines Pumpenhandbuch für Chemie und Technik, Verlag Chemie GmbH, Weinheim 1967). Other prime movers, such as internal combustion engines and turbines, are also used.

The main disadvantage with these pump assemblies is that, related to the dimensions when using the usual constructional form of the pump assemblies, it is impossible to obtain a greater delivery head while simultaneously maintaining a good efficiency, a good intake capacity and operational reliability with a constructional form which can be used economically. The cost of construction is too high in respect of production time, material consumption and dimensions.

The known multi-stage constructional forms of the pump assemblies of conventional type, which embody the existing prior art, are consequently not the most economical solutions. An additional factor is that the action in operation, more especially the behaviour as regards vibration and wear, is not satisfactory. It has more recently been attempted to obviate the disadvantages which have to be accepted with the design of assemblies having multi-stage centrifugal pumps by using single-stage centrifugal pumps having a high speed of rotation. On the assumption that, with a prescribed output, the diameter of the rotor is smaller as a higher driving speed is chosen, the entire pump assembly is all the more compact and economic as regards manufacture, supply, installation and in operation as the provided driving speed is higher, the behaviour thereof in operation being at the same time improved.

These considerations led to the development of a known single-stage or two-stage high-speed geared centrifugal pump for the output range V up to 160 m^3/h and delivery head H up to 1700 m.

The disadvantages of the relatively poor suction capacity are in this case reduced by an inducer connected on the input side of the high-pressure stage. The pump is driven electrically by a three-phase induction motor. The suction stage (inducer) and the high-pressure stage are seated on one shaft and run at the same speed of rotation. The vertical gearing arranged between the centrifugal pump and prime mover or driving motor converts the driving speed from $3000\ min^{-1}$ to output speeds which are in a range of $4000\ min^{-1}$. Provided inside the gearing are control instruments which supervise the operating conditions. A volumetric oil pump provides for a continuous circulation of lubricating oil inside the gearing. Filters and heat exchangers (Kleines Handbuch für Chemie und Technik, Verlag Chemie GmbH., Weinheim 1967) provide for the regeneration of the lubricating oil. An improvement in the design of the gearing has led to the oil pump and the heat exchanger being able to be eliminated, despite the high speed of rotation up to $40000\ min^{-1}$ (German Offenlegungsschrift 22 13 731).

The requirement for changing the delivery flow at the installed centrifugal pump assembly in the industrial plant is primarily allowed for, within certain limits, by the use of the uneconomic throttle control systems.

What is essentially more economic than the control by throttling means is the low-loss, stepless regulation of the speed of rotation. As regards the multi-stage and single-stage centrifugal pump assemblies, the economic infinitely variable change in the delivery flow is not readily possible, for example, with the known electric prime movers. All prior known devices used technically in connection with machines and industrial electrical equipment for the infinitely variable regulation of speed, as for example fluid clutches, control gears, high-frequency motors with frequency converters, direct-current motors with mercury vapor rectifiers, and the like, combined with the known multi-stage centrifugal pumps, are solutions which economically are expensive.

The object of the invention is to provide a high-pressure centrifugal pump assembly which technically and economically is more advantageous by comparison with the known constructional forms.

The invention has for its object to develop a high-pressure centrifugal pump assembly which is characterised by a greater delivery head while simultaneously achieving an efficiency which can be operated economically as regards energy, very good intake behaviour of the first stage and also by a low-loss delivery flow control while maintaining smallest possible dimensions and weights.

According to the invention, this object is achieved by the fact that a low-speed suction

or intake stage and one or more high-speed high-pressure stages are combined in a constructional form which radially is compact and with prime movers to form an assembly in a pump housing consisting of one or more parts and the driving of the intake stage and of one or more high-pressure stages is effected independently of one another with a constant or variable speed of rotation. The intake stage is directly driven by a known, low-speed prime mover which may or may not be controllable as regards speed and each high-pressure stage is driven by a known high-speed prime mover which may or may not be controllable as regards speed of rotation. In a further development, the invention is based on the fact that the intake stage is driven from a known, low-speed prime mover which may or may not be regulatable as regards speed and each high-pressure stage is driven by a known low-speed prime mover which may or may not be regulatable as regards speed, by way of a gear which is connected between the prime mover and high-pressure stage. The prime movers are known direct-current motors fed by way of diodes or thyristors as rectifiers from the alternating current or three-phase mains, frequency-controlled three-phase motors, internal combustion engines or turbines.

The invention is hereinafter to be more fully explained by reference to constructional examples.

In the accompanying drawings:

Figure 1 is a section through a two-stage radial high-pressure centrifugal pump assembly having a compact vertical or horizontal constructional form which is driven by direct-current motors having a contant or variable speed,

Figure 2 is a section through a two-stage radial high-pressure centrifugal pump assembly having a compact vertical or horizontal constructional form, with an interposed gear for driving the high-pressure stage and a three-phase induction motor,

Figure 3 is a section along the line A–A in Figs. 1 and 2.

In accordance with Fig. 1, a low-speed intake stage 1 and one or more high-speed high-pressure stages 2 are contained as a complete structural unit in a pump housing 5 consisting of one or more parts and having a radially compact vertical or horizontal constructional form.

The intake stage 1 is driven directly by a low-speed prime mover 4 the speed of which may but need not be adjustable. The high-pressure stage 2 is likewise driven directly and independently of the intake stage 1 by a high-speed prime mover 3 the speed of which may but need not be adjustable. Both the prime movers 3 and 4 are flanged on the pump housing 5.

In the embodiment illustrated in Fig. 2, the low-speed intake stage 1 is driven by a low-speed prime mover 9, the speed of which may but need not be adjustable.

The high-pressure stage 2 is likewise driven by a low-speed prime mover 7, the speed of which may but need not be adjustable, but via a gear 8 which is interposed between the prime mover 7 and the high-pressure stage 2.

The essential advantage of the invention consists in that a low-speed intake stage and one or more high-speed high-pressure stages are combined in a multi-stage high-pressure centrifugal pump assembly, with a compact radial arrangement and a vertical constructional form and the pump stages are operated independently of one another at a constant or infintely variable speed of rotation. What is thereby achieved is a very good intake behaviour and a high delivery head with an efficiency which is economically tenable as regards energy consumption, at the same time obtaining an economic manufacture, a high standard as regards utilisation of material and efficient running conditions.

CLAIMS

1. A multi-stage high-pressure centrifugal pump assembly for liquid comprising a housing including a low-speed intake stage and one or more high-speed high-pressure stages driven by prime movers, wherein the drive of the intake stage is effected independently of the drive of the high-pressure stage or stages.

2. A pump assembly according to Claim 1 wherein the intake stage is directly driven by a low-speed prime mover, the high-pressure stage or stages being directly driven by a high-speed prime mover, the prime movers being flanged on the pump housing.

3. A pump assembly according to Claim 1 wherein the intake stage is directly driven by a low-speed prime mover, the high-pressure stage or stages being driven by a further low-speed prime mover via a gearing which is interposed between the high-pressure stage or stages and the associated prime mover.

4. A pump assembly according to Claim 2 or 3 wherein each of the high-pressure stages is driven by its own prime mover.

5. A pump assembly according to any one of the preceding claims wherein the prime movers are direct-current motors, frequency-controlled three-phase motors, internal combustion engines or turbines.

6. A multi-stage high-pressure centrifugal pump assembly for liquid constructed, arranged and adapted to operate substantially as herein described with reference to, and as shown in, Figs. 1 and 3 or Figs. 2 and 3 of the accompanying drawings.

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ASSIGNEE-INFORMATION:

NAME	COUNTRY
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ABSTRACT:

CHG DATE=19990617 STATUS=O> A low-speed L.P. stage 1 and one or more high-speed H.P. stages 2 are located in a common housing 5 and independently driven. The driving motors 7 of the H.P. stage(s) may be of higher speed than the driving motor 9 of the L.P. stage. The motors may be of frequency-controlled three-phase type or may be of D.C. type fed with rectified current from a three-phase supply, or I.C. engines or turbines may be used. <IMAGE>

DERWENT-ACC-NO: 1979-J1983B

DERWENT-WEEK: 197939

TITLE: Two stage high pressure centrifugal pump - has stages driven independently at different speeds by separate motors for optimum performance

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PATENT-ASSIGNEE: SPENGLER H[SPENI] , VEB KOMB PUMPEN[PUMPN]

PRIORITY-DATA: 1978DD-0205614 (May 29, 1978)

PATENT-FAMILY:

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INT-CL (IPC): F04D001/06, F04D013/14

ABSTRACTED-PUB-NO: DD 136759A

BASIC-ABSTRACT:

The pump has a casing(5) in which a low pressure first stage(1) and a high
pressure second stage(2) are arranged side by side. The impeller of each stage
is mounted on its own shaft and the two shafts are parallel to each other.

The two shafts are extended through the back of the casing and each carries the
rotor of an electric motor. The two motors(3, 4) are bolted directly to the
back of the pump casing. The two motors can run at different speeds which
enables each stage to be designed for optimum performance independently of the
other.

TITLE-TERMS: TWO STAGE HIGH PRESSURE CENTRIFUGE PUMP STAGE DRIVE INDEPENDENT
SPEED SEPARATE MOTOR OPTIMUM PERFORMANCE

DERWENT-CLASS: Q56